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SUGAR

AND ITS VALUE AS FOOD

MARY HINMAN ABEL

U. S. DEPARTMENT OF AGRICULTURE

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THE fact that most persons enjoy the flavor of sugar, either alone or combined with other foods, is a very good reason why it should be included in our list of common foods. An equally good reason is that if sugar is used in moderation it is easily digested and the energy stored in it is very quickly released for the muscular work of the body. This bulletin tells something of the nature of sugar and its use in the well-planned diet.

Contribution from the States Relations Service

A. C. TRUE, Director

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CONTENTS.

SUGAR AND ITS VALUE AS FOOD.

INTRODUCTION.

The pleasant flavor of sugar, together with what is now known of its nutritive value, will account for its great popularity as a food. It may almost be said that people eat as much sugar as they can get, and that the consumption of sugar in different countries is in general proportional to their wealth.

The English-speaking people are the largest consumers of sugar. In 1910 England consumed 86.3 pounds per capita and the United States 81.6 pounds, although still larger amounts are said to be consumed in sugar-growing districts, largely in the form of the ripe cane. Denmark that year consumed 77.7 pounds per capita; Switzerland, 64.3 pounds; and Germany, France, and Holland each about 40 pounds; while in Italy, Greece, and Servia the rate was only about 7 pounds per capita. The consumption of sugar is everywhere increasing.

CHEMICAL COMPOSITION OF SUGARS.

The term "sugar," as here used without qualification, means the ordinary sugar of commerce, the chemical name of which is sucrose. Because this was first manufactured from sugar cane it is called cane sugar, but the same sugar is manufactured from beets and is known as beet sugar. It is also found in the juice of many other plants. There are other sugars which are also given popular names denoting their origin—for instance, milk sugar, grape sugar, and fruit sugar. The sugars may be conveniently divided chemically into several groups according to the number of carbon atoms which they contain. The most important from the standpoint of food value are the single sugars, grape sugar (dextrose) and fruit sugar (levulose), with 6 carbon atoms; and the double sugars, cane sugar (sucrose), milk sugar (lactose), and maltose (malt sugar), in which the molecule contains 12 carbon atoms, or twice as many as in the single sugars.[1]

[1] The brief statement of the chemical nature and names of different sugars and other carbohydrates which follows will perhaps make clear to housekeepers, as well as to others who are interested in such questions, this interesting part of the chemistry of food.

Carbohydrates are so named because they are composed of the elements, carbon, hydrogen, and oxygen, the hydrogen and oxygen being in the same proportions as in water, which is composed of 2 atoms of hydrogen to each atom of oxygen. Though there are carbohydrates with fewer than 6 and with more than 6 carbon atoms, the principal carbohydrates used as food contain 6 carbon atoms or multiples of 6. These

By a chemical process called inversion, which may occur in different ways (see pp. 7 and 15), one molecule of the double sugar is made to unite with water and form two molecules of single sugar. In nature two single sugars, dextrose and levulose, often occur in equal proportions, and the combination is then referred to as invert sugar.

Sugar belongs to the important group of food constituents, carbohydrates, so named because as a whole they contain the element carbon in chemical combination with oxygen and hydrogen, these two elements being in the same proportion as in water. Other carbohydrates closely related to sugar are starch and crude fiber, or cellulose. Sugars and starches are very important foodstuffs, since with fat they supply the bulk of the energy of the diet. Crude fiber, usually digested by man in limited quantities only, is, nevertheless, an important foodstuff, since it adds bulk to the diet.

CHARACTERISTICS OF CANE SUGAR.

Pure cane sugar consists of a mass of white crystals (e. g., the old fashioned "rock candy") easily soluble in about half their weight of cold, or in a small quantity of hot water. Cane sugar is about two and one-half times as sweet as grape sugar.

At 320° F., considerably above the boiling point of water (212° F.), sugar melts into a colorless liquid which rapidly takes on an amber hue. If it is then cooled quickly it hardens into a glassy mass, transparent and brittle, which is called "barley sugar." If heated to a higher temperature it browns, becoming less sweet and acquiring a somewhat bitter flavor. This browned sugar is called caramel. Old-fashioned brown sugar owed its color and flavor, at least partly, to caramel, for the process of manufacture formerly used involved evaporation over an open fire, which caused some of the sugar to become caramelized or half burnt, since in the final stages of sugar making the mass became so thick that it could not move about freely, and the layer next to the bottom of the kettle was raised far above the boiling point.

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are (1) monosaccharids (single sugars), including hexoses (such as dextrose, or grape sugar, and levulose, or fruit sugar), so called because the molecule contains 6 atoms of carbon with 12 atoms of hydrogen and 6 atoms of oxygen; (2) disaccharids (double sugars, such as cane sugar, and lactose, or milk sugar), so called because the molecule contains two of the simple sugar molecules less one molecule of water, namely, 12 atoms of carbon with 22 of hydrogen and 11 of oxygen; and (3) polysaccharids (such as starches), so called because the molecule contains repeated many times the simple sugar molecule minus the molecule of water or 6 atoms of carbon, with 10 of hydrogen and 5 of oxygen. When a molecule of water combines chemically with a molecule of the second group, two hexose molecules are formed, and when the necessary number of molecules of water combine chemically with a molecule of the third group, two or more hexose molecules are formed. This process, called inversion or hydrolysis, may occur in several different ways.

Each group of sugars contains a number of members; for example, grape sugar and fruit sugar have the same chemical formula and the same percentage of carbon, hydrogen, and oxygen, although they are not identical substances. The difference in their properties is due to different groupings of the atoms. This must not be confused with the fact that the same sort of sugar may be obtained from widely different sources. Thus grape sugar is found in grapes and other fruits, and cane sugar is found in the juice of the sugar cane, beets, carrots, and other plants.

CHARACTERISTICS OF OTHER KINDS OF SUGAR.

Dextrose and Levulose.

Besides cane sugar, the commonest kinds are dextrose or grape sugar, very much less sweet than cane sugar, and levulose, very much sweeter than dextrose. These two sugars are usually found together. Dextrose may be seen in yellowish grains in the raisin and other sweet dried fruits. It exists in small quantities in many fruits, but occurs chiefly as a manufactured product, a result of the hydrolysis of starch, which means causing it to unite chemically with water by heating it with dilute acids or in some other way to induce hydration. By this treatment cane sugar is split up into a mixture of dextrose and levulose known as "invert" sugar, which is also a commercial product. Honey is practically a natural form of invert sugar in which there is usually more levulose than dextrose.

More sugar is supposed to be required to sweeten acid fruits if it is added before cooking than if it is added afterwards, and this is ascribed to the change of the cane sugar into invert sugar under the influence of the acid and heat. Miss Jennie H. Snow [1] found that the amount of sugar inverted depends upon the length of time it is cooked and the degree of acidity, and her conclusions are borne out by the results of European investigators. She found, however, that loss of sweetness due to cooking sugar with acid fruit is so slight as to be of little practical consequence. The effect of heat and acids in "inverting" cane sugar, as it it is termed, and also in destroying these sugars, has to be kept in view constantly in the manufacture of sugar. By the slow methods formerly in use on the sugar plantations, the juice of the cane soured before it was boiled, and the acids so formed inverted much of the cane sugar under the influence of heat. This hindered crystallization, as did also the caramel produced by the overheating of a portion of the juice. The hindering of undesired crystallization by inversion with the aid of a little acid is sometimes very important in sugar making. Similarly, manufacturers of candy know that if they wish to prevent crystallization or "graining" of a concentrated solution of sugar, as in making "fondant" or soft filling, tartaric or other acid must be added to invert some of the sugar.

The change of cane sugar in solution to dextrose and levulose mentioned above may be brought about even in the absence of acid, by the action of heat, or by certain ferments, such as invertase, an enzym of yeast.

Milk Sugar.

Milk contains from 4 to 5 per cent of another important sugar—milk sugar or lactose. When separated and purified it is a crystalline

[1] Jour. Hom. Econ., 1 (1909), No. 3, pp. 261–266.

product and is sold in that form. It is said to be the most readily digestible sugar and is often found in prepared foods, especially those made for invalids and children. It is much less sweet than cane sugar.

Honey.

Before sugar was a common commercial product, honey, stored by the honeybee, was very generally used to sweeten foods. Although its use for this purpose is much less common since cane sugar has become so plentiful and cheap, honey is still highly prized as a wholesome sweet food and is used either alone or with other foods in a great many ways. It consists of a natural mixture of dextrose and levulose (about 37 per cent of each) and may contain as high as 6 to 8 per cent of sucrose. An average analysis shows 74.41 per cent of reducing sugar calculated as invert sugar, and 1.98 per cent of sucrose.[1] It also contains an average of 17.59 per cent of water and 0.23 per cent of mineral matter. Its flavor is due to volatile bodies in the flowers from which it is obtained, some flowers imparting a more agreeable flavor than others to the honey. It was formerly assumed that its composition was practically the same as that of the nectar gathered by the bees, but recent investigation shows that the nectar undergoes certain changes in the honey sack of the bee, and that the chemical properties of honey are not quite like those of the nectar. Its behavior in cooking and storing is different from that of the ordinary sugars for reasons not yet thoroughly understood. Honey has been used as a food from the earliest times, and is generally conceded to be wholesome as well as palatable. Prior to the passage of the Federal pure-food law, in 1906, strained honey was very frequently adulterated with commercial glucose (see p. 9) and other materials, such as commercial invert sugar, but since this law went into effect there is little adulteration of this product. Mixtures with glucose and invert sugar are sold, but the law requires that they be so labeled.

Japanese Ame.

A sweet material called ame has been made in Japan since early times from glutinous rice or glutinous millet, sometimes from common rice and rarely from Indian corn or sweet potatoes, by converting the starch they contain into maltose (a double sugar similar to sucrose, lactose, etc.) by the action of an unorganized ferment called diastase. Malt or sprouted barley is generally used to furnish the ferment. The cleaned grain or other material is soaked in water and steamed until the starch grains are broken open and made easily accessible to the ferment. Powdered malt and water in proper proportions are added, and in six or eight hours the diastase converts the starch very largely into dextrin and maltose. The liquid is then filtered and evaporated to the desired consistency, which varies

[1] U. S. Dept. Agr., Bur. Chem. Bul. 110.

according to the season. One of the forms is a dense, clear, light-colored amber liquid not unlike the best commercial glucose in some of its physical properties. Another form is hard and not unlike a white candy in appearance. Ame has been manufactured in Japan for at least two thousand years, and long before sugar was known it was a favorite flavoring. Even at the present time it is sometimes used instead of sugar in cooking, and it is also a favorite food adjunct for invalids.

Malt Sugars.

Several malt preparations, some of them thick like sirup and others more of the consistency of candy, are on the market. These are mixtures of dextrin and maltose coming from the action of diastase on starchy materials. Many commercial products, so-called "predigested" and "malted" products and similar goods, have this material as their basis.

Glycogen.

Glycogen or "animal sugar" is a carbohydrate of the same chemical composition as starch, but with different chemical properties. It is found in small amounts in muscular tissue, and more abundantly in the liver, where it may exist in considerable quantities. It has an important function in nutrition, being stored as a reserve source of energy for the body.

SWEET MATERIALS OTHER THAN SUGAR.

Saccharin, an extremely sweet material, is not a sugar, but is of an entirely different chemical structure, being a benzene compound. Its use in food products was forbidden under the Federal pure-food law.[1] It is quite commonly prescribed in cases of diabetes to satisfy the craving for sweets, as it is believed to be less harmful in such cases than the sugar, the flavor of which it replaces.

There are other chemical substances which are not sugars, but which have a marked sweet flavor. They, like saccharin, are in no sense foodstuffs.

COMMERCIAL GLUCOSE AND OTHER COMMERCIAL PRODUCTS MADE FROM STARCH.

"Commercial glucose," "40 sugar," "80 sugar," and "commercial dextrose" are commercial products of the hydrolysis of starch. The first is a thick liquid, rarely showing crystallization, having a composition of between 30 and 39 per cent dextrose, 40 to 53 per cent dextrin, and about 0.5 per cent ash. The others are solid products varying in percentage of dextrose up to 95 per cent, with small quantities of dextrin.

[1] U. S. Dept. Agr., Food Insp. Decisions 135, 138, 149.

Commercial glucose is often used as a substitute for sugar in sirups, candy making, preserving, etc. Confectioners maintain that certain kinds of candy can not be made of as good consistency with pure cane sugar as with the addition of some glucose. In such cases it can hardly be considered an adulterant. When it is used as a cheaper substitute for cane sugar, and the goods are sold as cane-sugar products, its use is evidently fraudulent. The present law in the United States requires that sirups, jams, jellies, etc., made with glucose, shall be so labeled. Its nutritive value is practically the same as that of other carbohydrates, and there is no reason to suppose that when properly made it is not wholesome.

SOURCES OF CANE SUGAR.

Cane sugar, beet sugar, sucrose, or simply "sugar," as it is known to commerce and in the household, exists in solution in many vegetable juices. It is found in the stems and roots of the grasses, especially in the sugar cane, sorghum, and cornstalks; in fleshy roots, as the beet, carrot, turnip, and sweet potato; in the sap of trees, as the date palm and sugar maple; in almost all sweet fruits; and in the nectar of flowers. Only in a few of these, however, is the proportion of cane sugar large enough to make profitable its separation from the other substances which these juices hold in solution.

In fact, the cane and sugar beet are the only important sources of sugar (sucrose). Of the world's crop of 16,418,500 tons in 1910–11, 8,321,500 tons were made from cane, and 8,097,000 from the beet.

Sugar is a staple article of food, just as is bread or meat, but few realize that, unlike bread and meat, it has been a staple food for but a few generations. The art of manufacturing it has been developed very rapidly within the last 125 years. Only, indeed, in the last three-quarters of a century has it been produced in such quantities and at such a price as to bring it into really general use.

SUGAR FROM THE SUGAR CANE.

The sugar cane is a gigantic jointed grass with the botanical name *Saccharum officinarum*, native to eastern India and China, numerous varieties of which are now grown in the tropical and subtropical regions of both hemispheres.

Sugar from the sugar cane was probably known in China 2,000 years before it was used in Europe. When merchants began to trade in the Indies, sugar, like spices, perfumes, and other rare and costly merchandise, was brought to the western countries of Europe, and for a long time it was used exclusively in the preparation of medicines. An old saying to express the lack of something very essential was "Like an apothecary without sugar." Several centuries before the Christian Era Greek physicians knew of sugar under the name of "Indian salt." It was also called "honey made from reeds," and was

said to be "like gum, white and brittle." But not until the Middle Ages did Europeans have any clear idea of its origin. It was confounded with manna or was thought to exude from the stem of a plant, where it dried into a kind of gum. When in the fourteenth or fifteenth century the sugar cane from India was cultivated in northern Africa, the use of sugar greatly increased, and as its culture was extended to the newly-discovered Canary Islands and later to the West Indies and Brazil, it became a common article of food among the well-to-do. By many the new food was still regarded with suspicion. It was said to be very heating, to be bad for the lungs, and even to cause appoplexy. Honey was thought to be more wholesome, because more natural than the "products of forced invention." The sugar-growing industry in what is now the United States dates from 1751. It has developed into a great enterprise, as has also sugar refining.

SUGAR FROM THE SUGAR BEET.

The sugar consumed in this and other countries up to 1850 was nearly all derived from the sugar cane, but at the present time one-half of the sugar crop is obtained from the sugar beet. Between 1863 and 1883 Germany, one of the leading beet-sugar producing countries, increased its output 338 per cent. It would once have seemed incredible that the kitchen garden should furnish a rival for the "noble plant" that had made the fortunes of Spanish and English colonies, but the cultivation of the beet for sugar has in one generation shifted the center of the sugar industry from the Tropics to the Temperate Zone. This growth has been fostered by strange vicissitudes in the fortunes of nations, such as the commercial embargoes and sugar bounties of the Napoleonic wars, and the abolition of slavery in the British colonies, giving, as it did, a temporary check to the growth of the cane, aided in the creation of the beet-sugar industry. The real creators of the new industry, however, were men of scientific training who solved certain botanical and chemical problems.

In 1747 Marggraf, a chemist of Berlin, discovered that beets and other fleshy roots contain a crystallizable sugar identical with that of the sugar cane. In 1799 the subject was brought before the French Academy, and in 1801 the first manufactory for beet sugar was erected. It had been manufactured as early as 1797, but the 2 or 3 per cent of sugar that could be extracted by the methods then in use was too little for commercial success. A new stimulus was given by the sugar bounties of Napoleon in 1806, and methods improved rapidly, especially in France. Two great difficulties still remained: The percentage of sugar present in the beet was small (5 per cent), and it was only with great difficulty that it could be separated from the many other constituents, some of them acrid and having a very unpleasant flavor. Science now came to the aid of the industry, and a beet was gradually developed with a larger percentage of sugar and

a smaller percentage of the undesirable impurities. Eighteen tons of beet roots were necessary in 1836 to produce 1 ton of sugar; in 1850, this quantity was reduced to 13.8 tons; in 1860, to 12.7 tons, and in 1889, to 9.25 tons. From 5 per cent of sugar, as found by Marggraf, the sugar beet of good quality, thanks to the scientific work which has developed it, now contains 15 per cent and more, at least 12 per cent being considered necessary for profitable manufacture.

SUGAR FROM THE SUGAR MAPLE.

The sugar maple of North America is also a source of sucrose, the trees being tapped in the early spring to obtain the sap as it flows upward through the trunk on the way to the branches. This sap on boiling yields its 2.5 per cent of sucrose and a few nonsugars in a more or less moist, brown, crystalline mass, which can be refined until it is like other pure sucrose. However, on account of the pleasant flavor the product in its crude form sells for a better price than would the refined sugar. Five gallons of sap yield about a pound of sugar. Equally popular is the maple sirup; that is, the sap which has been boiled down, but not enough to crystallize.

It is said, apparently on good authority, that maple sugar was made by the American Indians for an untold time before Europeans came to this continent. It is interesting to read a paragraph from a book written by the eminent Robert Boyle and printed at Oxford in 1663:

> There is in some parts of New England a kind of tree * * * whose juice that weeps out of its incisions, if it be permitted slowly to exhale away the superfluous moisture, doth congeal into a sweet and saccharin substance, and the like was confirmed to me by the agent of the great and populous colony of Massachusetts.

Maple sugar was also appreciated in colonial times for making sweets as well as for use as a staple article of diet, for early records mention a "nut sweet" made from maple sugar, butter, and nuts, the sugar being melted and slightly browned in order to impart a caramel flavor in addition to the maple flavor.

Occasionally, by a method similar to that by which maple sugar is obtained, sugar is made, or was made in colonial times, from the sap of the butternut tree, and, it is said, from the birch also.

According to the Preliminary Report of the United States Census for 1910, the total quantity of maple sugar produced in this country in 1909 was 14,060,206 pounds and the total amount of maple sirup was 4,106,418 gallons.

QUALITY OF SUGAR FROM DIFFERENT SOURCES.

The methods used in the manufacture of sugar are all devised to separate the sugar from the other constituents of the juice. The juice containing the sugar is expressed or extracted from the cane,

beet, etc., treated to remove the nonsaccharin substances which prevent crystallization, and evaporated in vacuum apparatus to prevent burning; the sugar is then crystallized, and the crystals separated from the molasses in centrifugals. Modified methods of manufacture may produce white granulated sugar direct from the beet or the cane. When these are not used, the product is "raw sugar" which must be passed through some refining process before it is white sugar. The methods of manufacturing sugar from the beet are described in a previous bulletin of this series.[1]

The average composition of raw sugar from a number of different sources is as follows:

Average composition of raw sugar.

Sugar from—	Water.	Cane sugar.	Other organic substances.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sugar cane	2.16	93.33	4.24	1.27
Sugar beet	2.90	92.90	2.59	2.56
Maize	2.50	88.42	7.62	1.47
Palm	1.86	87.97	9.65	.50
Maple	7.50	82.80	8.79	.91

Raw sugar from these various sources takes on in each case the character of the impurities from which it has not yet been freed. Thus, the raw products of the sugar cane, maize, and the sugar maple, are pleasant in flavor, that of the beet is acrid and disagreeable, while the raw palm sugar or jaggary is of low sweetening power, because of the large amount of invert sugar (dextrose and levulose, see p. 7) that has resulted from fermentation and too high a degree of heat used in evaporation. From all these raw sugars the pure cane sugar, or sucrose, as known to the chemist, can be crystallized out, and in every case the sugar is identical in chemical composition, appearance, and properties. By no chemical test can the pure crystallized sugar from these different sources be distinguished. There is a popular impression to the contrary, however, and it is often asserted that beet sugar has less sweetening power, or that fruits preserved with it do not keep as well, but this can be true only of specimens that have been imperfectly purified.

Tests made at the California Experiment Station [2] led to the conclusion that the two sorts of sugar were equally valuable for canning, and identical in their behavior when of the same fineness of crystallization.

Methods of refining raw sugar have been so improved in the last few years that it may be truly said that few food substances are so nearly pure chemically as the best granulated or lump sugar.

[1] U. S. Dept. Agr., Farmers' Bul. 52.

[2] California Sta. Circ. 33.

PURITY OF SUGAR.

Of 500 samples of sugar examined several years ago by the Bureau of Chemistry of this department,[1] not one was found to be adulterated. The low price of cane sugar, in comparison with the price of substances that might be used for adulteration, protects it from such attempts.

A more recent publication of the Bureau of Chemistry[2] states that sugars as a class, both the high and low grades as now found on the market, are practically free from adulteration. This is particularly true since the Federal pure-food law of 1906 went into effect.

There is a popular belief that granulated sugar is often adulterated with white sand or finely ground rock, and that pulverized sugar is commonly adulterated with starch or lime dust. Cases of such adulteration, however, have rarely been found by the Bureau of Chemistry, though starch has been detected in a very few samples of powdered sugar. It is a very simple matter to test suspicious sugar for the presence of such materials. Sugar is readily soluble in water, and the sand and mineral adulterants are insoluble. If a spoonful of sugar is added to a glass of water and stirred, it will completely dissolve, while any sand or similar material will remain undissolved. If the water is warm the sugar will dissolve more quickly than otherwise, and care must be taken to continue the stirring for considerable time, as some of the very dry crystalline sugars dissolve rather slowly.

FOOD VALUE OF SUGAR.

The most interesting use of sugar is as a food for the animal body. Within certain limits, sugar may be considered as the equivalent of starch that has been digested and made ready for absorption. A mealy boiled potato, like all forms of starchy food, must be largely converted into some kind of sugar by the digestive juices before it can be absorbed as food.

It is commonly stated that the food eaten by the average adult is at least one-half of vegetable origin, and analyses show that the nutrients of vegetable foods are very largely starch. The average of 400 dietary studies made in the United States shows about 40 per cent animal food and 60 per cent vegetable food. Starch in cereal grains and other foods, and separated as cornstarch, etc., furnishes a considerable part of the heat and muscular power of the body. The summary of data regarding the American diet quoted above shows that sugar constitutes 5.4 per cent of the average diet and furnishes 17.5 per cent of the total energy in it. It is clear that starch, sugar, or any food that will serve the same purpose is of great importance.

To understand the utilization of such foods in the body better, the process of carbohydrate digestion may be considered. When a

[1] U. S. Dept. Agr., Div. Chem. Bul. 13, pt. 6. [2] U. S. Dept. Agr., Bur. Chem. Bul. 100.

starchy food, such as boiled potato, is taken into the mouth, it is at once acted upon more or less by a ferment contained in the saliva, and this action is continued by a ferment contained in the intestines. It is broken up into simpler chemical compounds, and it finally reaches the blood and muscles as dextrose, a form of sugar which can be burned in the body to yield muscular energy and heat. When an excess of carbohydrates (sugar or starch) is consumed, the dextrose in the digestive tract is converted in the liver to glycogen and stored until required, being then, it is believed, reconverted into dextrose. More complex changes may take place which convert carbohydrates consumed in excess into fat, which is also stored as a reserve material.

Some recent German investigations indicate that the different kinds of sugar are not equally well adapted to increasing the supply of glycogen in the body. In experiments with dogs, sucrose and dextrose proved the most valuable in this respect.

DIGESTION OF SUGAR.

When sugar is eaten it is changed in the digestive tract before it is taken up in the blood and carried where it is needed. If a solution of cane sugar be injected directly into the blood, it is passed out by the kidneys unchanged, showing that it is not fitted for assimilation until it has been changed, as it is in normal digestion. The change needed is slight compared with that required for the digestion of starch, sugar being "inverted" or changed into the simpler sugars as already described (see p. 7), and this change is brought about in the digestive tract by the agency of enzyms or ferments regarding the nature of which little is known. When thus changed into the simpler sugars, its function in the body is similar to that of starch after it has reached the analogous stage in digestion.

At the Minnesota Experiment Station[1] the thoroughness of digestion of sugar was studied with healthy men, 5 ounces per day being consumed as part of a simple mixed diet. The sugar showed a high digestibility, 98.9 per cent of its total energy being available to the body, on the average. In general, it increased the available energy of the whole ration 25 per cent and did not affect the digestibility of the foods with which it was combined. The protein of the ration was more economically used than commonly, the nitrogen retention being increased 25 per cent. It was pointed out in discussing these experiments that "the value of sugar in a ration depends upon its judicious use and combination with other foods."

SUGAR AS A FOOD FOR MUSCULAR WORK.

Food must supply enough protein or nitrogenous material for the formation and repair of tissues and for certain other uses in the body, and in addition sufficient other material to make up the amount of

[1] Minnesota Sta. Rpt. 1903–4.

energy necessary for heat and muscular work. The nitrogen-free nutrients are fats and carbohydrates. In the ordinary diet the relative amount of fat and carbohydrates is usually regulated by personal preference. Fat will furnish two and one-fourth times as much energy per pound as carbohydrates. Taking account of this fact it is immaterial on chemical grounds which of these nutrients supplies the necessary energy, although this is not the case from the standpoint of hygiene.

The main function of sugar as found in the blood, whether resulting from the digestion of sugar or of starch, is believed to be the production of energy for internal and external muscular work, and, as a necessary accompaniment, body heat. This has been amply demonstrated by experiment. By ingenious devices the blood going to and from a muscle of a living animal may be analyzed, and it is thus shown that more blood traverses an active or working muscle and more sugar disappears from it than is the case with a muscle at rest.

To decide the question of the value of sugar as a source of energy for the working muscle, much careful laboratory work has been carried on. It has been found that an increase in the sugar content of the diet, when not too great and when the sugar is not too concentrated, lessens or delays fatigue and increases working power. Increased amounts of sugar were found to increase the ability to perform muscular work to such an extent that on a ration of 500 grams (17.5 ounces) of sugar alone a man was able to do 61 to 76 per cent more work than on a fasting diet, or almost as much as on a full ordinary diet. The addition of about half this quantity of sugar to an ordinary or to a meager diet also considerably increased the capacity for work, the effect of the sugar being felt about a half hour after eating it, and its maximum effect showing itself about two hours after eating. The coming of fatigue was also found to be considerably delayed on this diet, and taking 3 or 4 ounces of sugar a short time before the usual time for the occurrence of fatigue prevented the appearance of it. Lemonade, or other similar refreshing drink, and chocolate have been suggested as mediums for supplying in small doses an extra amount of sugar to men called upon to perform extraordinary muscular labor. The application of these results to the food of soldiers who may be called upon for extraordinary exertion in marching or fighting is very evident. Practical tests of the value of sugar in preventing or delaying fatigue, made in both the German and French armies, indicate the value of sugar in the ration when the men are subjected to great exertion.

It is believed that more decisive results may be obtained by tests with men and animals in which the effects of given quantities of sugar in the diet are compared with those obtained with starch and other food materials. Such experiments have been made

under the auspices of this department with men in the respiration calorimeter. This apparatus makes it possible to measure with great accuracy the relation between the material consumed and the muscular work done. In experiments planned to test the value of carbohydrate foods as a source of energy during severe muscular work, the subjects were able to include 350 grams, or about three-quarters of a pound, of cane sugar in their daily diet without any deleterious effects.[1]

According to our present knowledge the value of sugar as a food for muscular work may be briefly summarized as follows:

When the organism is adapted to the digestion of starch, and there is sufficient time for its utilization, sugar has no advantage over starch as a food for muscular work.

In small quantities and in not too concentrated form sugar will take the place, practically weight for weight, of starch as a food for muscular work, barring the difference in energy and in time required to digest them, sugar having the advantage in these respects.

It furnishes the needed carbohydrate material to organisms that have little or no power to digest starch. Thus, milk sugar is part of the natural food of the infant whose digestive organs are, as yet, unable to convert starch into an assimilable form.

In times of great exertion or exhausting labor, the rapidity with which it is assimilated gives sugar certain advantages over starch and makes it prevent fatigue.

This latter quality, which renders it more rapidly available for muscular power, may account for the fact that sugar is so relished by people who are doing muscular work, and by those of very active habits, such as children.

The American farmer ranks high among agriculturists as a rapid and enduring worker, and his consumption of sweets is known to be very large. The same is true of lumbermen and others who work hard in the open air; sugar and sweet cakes are favorite foods with them. Dietary studies carried on in the winter lumber camps of Maine showed that large quantities of cookies, cakes, molasses, and sugar were eaten, sugar of all sorts supplying on an average 10 per cent of the total energy of the diet.

The value of sugar in cold climates, where foods containing starch are not available, is evident, and in the outfit of polar expeditions sugar is now given an important place.

Oriental races are very fond of sweets, as often noted by travelers. Certain forms of confectionery are very popular in Turkey and other regions of the East, and in tropical lands the consumption of dates, figs, and other sweet fruits is very large. In a discussion[2] of the food of the natives of India the great value set on sweetmeats or sugar

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 175.

[2] Jour. Trop. Med. [London], 9 (1906), p. 310.

by the Hindoo population of all classes is pointed out. Large quantities of brown or white sugar are used to sweeten the boiled milk, which is a common article of diet, and sugar is also used with sour milk, rice, cheese, and other foods. It has also been said that the employer who will not furnish the native laborers with the large amounts of sugar they desire in their daily ration must expect to lose his workmen.

Certain rowing clubs in Holland have reported very beneficial results from the use of large amounts of sugar in training.

Pflüger, who devoted so much attention to glycogen and other carbohydrates, says that undoubtedly sugar in the blood is heavily drawn on during violent exercise; hence the longing for it in a form that can be rapidly assimilated.

Its use by mountain climbers is well known. The Swiss guide considers lump sugar and highly sweetened chocolate an indispensable part of his outfit.

This brief summary serves to show the use which is made of sugar when severe work is performed, and some of the experimental data which indicate that this custom is justified.

SUGAR AS A FAT FORMER.

Sugar, like starch, is fattening; that is, when taken in excess it may be transformed into fat and stored as reserve material. On this account physicians commonly advise that sugar be sparingly used by the corpulent. This advice is given because sugar in the form of candy or other sweets is often taken as an accessory to an already abundant diet.

A practical illustration of the use of sugar as a fattening food is found in the use of both sugar and molasses in fattening farm animals, the fat so produced being found firm and of good quality. In sugar-producing regions it is a common constituent of the rations of horses and mules, and it is fed to dairy cattle and to fattening steers. In Louisiana, for example, it is the usual practice to feed "black strap" molasses to plantation horses and mules at the rate of 8 to 12 pounds per head per day. So common has its use become for farm animals in general that many mixed rations are now on the market which contain molasses as one of their chief constituents. Sometimes the materials added are used principally to absorb the molasses and make it more convenient to feed. The molasses, of course, contains practically no protein, the body-building material, and frequently materials are mixed with it which are rich in this constituent in order that the mixed feed may constitute a well-balanced ration.

SUGAR AS A FLAVOR.

In addition to its value as a food, sugar is important in the diet as a flavor, one which the cook could not easily spare, as it now enters into

a great variety of dishes. Indeed its agreeable flavor has always constituted one of the chief reasons for its use, and will continue to do so, even though we make use of the abundance of relatively cheap starchy materials we possess which theoretically may readily take the place of sugar as a food.

In some dietary studies made under the auspices of this department with a club of students at the University of Maine, an investigation was made of the effect of supplying a liberal amount of maple sirup in a diet which contained an abundance of nutrients. The sirup was evidently relished, and considerable amounts were eaten. However, there was not a corresponding decrease in other foods; on the contrary, the amount of flour was in excess of the amount ordinarily consumed. It would seem that the maple sirup, and flour in the form of griddlecakes, were consumed simply on account of their agreeable flavor. Provided the diet contained sufficient nutrients in the first place, this increase was not desirable on the ground of economy, and it may be questioned whether it was desirable from the standpoint of health. When a similar comparison was made of the addition to the diet of liberal quantities of milk, which has a much less distinctive flavor, there was a corresponding decrease in the amount of other foods consumed. This would indicate that much of the sugar used is consumed for its agreeable flavor and not because it is recognized as a food which is required to satisfy body needs.

FOOD VALUE OF TABLE SIRUPS AND MOLASSES.

Sirups of various kinds and molasses have always been used to a large extent in the United States as articles of diet and for cookery. There are several forms in common use. Of these, maple sirup, which is obtained by evaporating the sap of the sugar maple, commands the highest price. Cane sirup made from the expressed juice of the sugar cane is another important sirup, as is also the sirup made from sorghum by methods very much like those used in the manufacture of sirup from sugar cane. Very much used, too, are the homemade sirups obtained by boiling sugar, either white or brown, with water. A little caramel made by burning sugar in a frying pan and dissolving it in water may be added to the sirup to give both color and flavor. Some housekeepers add a little vinegar to homemade sirup, which imparts a flavor and inverts more or less of the sugar. Sometimes water in which several corncobs have been boiled is used in making homemade sugar sirups, the cobs imparting a flavor which many relish and which is said to suggest maple. In Europe a sirup called "whey honey" is made by boiling down, with sugar, the whey drained from cottage (sour milk) cheese until it is thick as honey, the proportions being 1 pound of sugar to a quart of whey. This has a pleasant and distinctive flavor.

An interesting example of the use of molasses in quantity is furnished by the negroes in some regions of the Southern States. Dietary studies in the Black Belt of Alabama showed that the diet was made up almost entirely of molasses, frequently homemade, corn meal, and fat pork.

The different grades of molasses obtained as by-products in the manufacture of sugar from sugar cane have always been popular as table sirups and for cookery. Molasses produced by the open-kettle process of boiling is the most highly appreciated, and for a long time was a staple article for both purposes. Generally speaking, it can now be obtained only in the Southern States and there in small quantities only, since the modern process of sugar making has practically eliminated this open-kettle molasses from the market. To supply its place, the manufacture of sirup directly from the sugar cane and without the separation of any kind of sugar has come to be practiced extensively in the South, particularly in Georgia, Florida, Alabama, Mississippi, and Louisiana. According to an early publication of this department, "this sirup forms a delicious, wholesome, and valuable condimental food substance, the use of which is rapidly extending; and, because of its merits, it appears destined to become a very important food."

For some reason the public has come to judge sirup largely by its color. Many prefer a dark product for cooking, partly because it colors the material with which it is mixed, and partly because the dark color is still associated in their minds with the flavor of old-fashioned molasses. For table use, however, a light-colored sirup is usually preferred. In this case the fact has apparently been overlooked that if properly manufactured good sirup must possess some color, since in the evaporation of the sugar juice in an open kettle or pan a high temperature is employed, which causes an inversion of some of the sugar, and also has a tendency to produce caramel which imparts a color to the sirup. Though a light-colored sirup is popular, a brown color does not mean that the sirup is not of good quality.

There are also in use in this country quantities of table sirups which are simple mixtures, the chief ingredient of which is commercial glucose, and the flavor of which comes very largely from some of the sirups and molasses mentioned above. In certain of these mixtures which owe their flavor and color to "refining sirup," a by-product of the sugar refinery, the content of soluble salts is large enough to impart a distinct saline flavor. The bone black used in purifying the sugar also affects the flavor of "refining sirup." Since the Federal pure-food law was enacted such mixtures bear a label showing the constituents.

Sugar-beet molasses is not used for table purposes, as no way has been found to free it commercially from objectionable impurities.

NUTRITIVE VALUE OF SUGAR CANE.

The entire juice of the ripened sugar cane is, of course, more nearly a complete food than its crystallized sugar, for it contains other constituents besides carbohydrates. It is elaborated by the plant as a rich food for building up young leaves and buds. In sugar-producing countries the cane is regarded as a staple food during its season. All classes of people chew the ripe cane freed from its hard rind, incredible quantities being consumed in this way. Shiploads are brought daily to the markets of Rio Janeiro and West Indian towns. For months the chief food of the negro laborers on the plantations is said to be the sugar cane, and they are seen to grow strong and fat as the harvesting season advances, although they may begin it weak and half-starved.

PRACTICAL USE OF SUGAR IN THE ORDINARY DIET.

Sugar was formerly regarded as a condiment and valued chiefly for its pleasant taste, but its food value has been fully established and, considering the immense quantities at present consumed, it is very important to determine the extent of its usefulness in dietaries.

It has been ascertained that in large numbers of well-to-do families in this country about 2 pounds per week per person are consumed. It would seem that this amount, or about one-fourth of a pound daily, taken in addition to other food, is well utilized by the system. There is some question regarding the desirability of using larger quantities. The use of sugar it would seem should be limited in two ways: (1) The amount consumed should not be greater than may be readily assimilated, else it would overload the stomach and bring on digestive disturbances and in some cases might produce pathological conditions in the excretory organs; and, (2) the sugar should not be taken in a solution or other form so concentrated that it causes a burning sensation or other digestive disturbance (see p. 22). The question of possible permanent injury from the use of fairly large amounts of sugar seems to be an open one, and certainly the extreme views which are sometimes found in popular writings do not seem to be entertained by well-informed physiologists, the conclusion generally accepted being that used in reasonable amounts sugar is both wholesome and nutritious.

AMOUNT AND CONCENTRATION.

Sugar differs greatly from starch in the amount that can be properly used in the system. Starchy foods, such as potatoes, bread, etc., can be digested and utilized in very large quantities. As much as 600 grams (1.3 pounds) of starch per day may be digested for many days without difficulty. This amount of starch is contained in 2.5 or 3 pounds of bread, or in 6 or 7 pounds of potatoes. Fewer tests have

been made regarding the maximum amount of sugar that may be used by the system. Vaughan Harley used large quantities of sugar in some of his experiments on himself, but 400 grams (nearly a pound) daily for some time very much affected his digestion.

Since, as scientific investigators seem agreed, the digestion of sugar is relatively so rapid, assimilation and storage in the liver can not keep pace with its absorption from the intestines if it is taken in large quantities. In this case, part of the sugar will be excreted unchanged. Not only is this excess of sugar wasted, but such an unnatural tax on the excretory organs, if constant and long continued, might end in disease. It is also a matter of common observation that large amounts of sugar and sweetened food are apt to be accompanied by undue fermentation in the stomach and intestines. If this occurs it shows that the quantity of sugar eaten is too great.

In this regard, investigators have pointed out that sugar bears much the same relation to starch that peptone, one of the products of meat digestion, does to meat. Both sugar and peptone are very diffusible, and thus enter rapidly into the circulation, strong solutions at the same time irritating the mucous membrane with which they come into contact by virtue of their water-abstracting power. The "furry" feeling noticed when a piece of hard candy is held in the mouth for some time against the cheek is a familiar example of the effect produced on sensitive membrane by a concentrated solution of sugar, which is undoubtedly due to the fact that equilibrium of density is not readily established between the liquid of the two sides of the membrane. The digestive disturbances noted when very concentrated solutions of sugar or other substances are taken into the stomach are attributed to similar causes; that is, to differences in the density of solutions on the two sides of the living membrane.

Doubtless because sugar is commonly excluded from the diet of diabetics the statement has been made that eating sugar is the cause of this disease, which of course does not follow. Such an opinion is not entertained by physiologists, as is apparent from the statement in a recent report [1] of the Connecticut State Agricultural Experiment Station, which shows the fallacy of such a belief. That sugar, honey, sirup, etc., "produce diabetes" would, according to the report, be "startling if true."

It is sometimes said that sugar produces gout. There seems to be no proof of this theory.

Sugar seems ill adapted to the sick, except when used in very small quantities as a flavor. Jacobi [2] remarks that the absorption of sugar is slower by sick than by healthy children, and that in such

[1] Connecticut State Sta. Rpt. 1911, pt. 2, p. 161.

[2] Therapeutics of Infancy and Childhood. Philadelphia, 1896, p. 16.

cases only a little should be given and never in concentrated form. He also states that the conversion of milk sugar into lactic acid takes place very rapidly, while cane sugar is not so readily transformed, and accordingly he insists that the latter be added to the food of infants and children.

When any bad effects can be ascribed to sugar they are usually due to its use in larger quantities than the 3 or 4 ounces a day which seem to be digested by the healthy adult without difficulty. The conclusion to be drawn from such experimental work as that referred to is that overeating with sugar is to be avoided, not, as has sometimes been stated, that sugar is other than a useful foodstuff.

The statement is sometimes made that sugar is unwholsome because it has been separated from the plant and is therefore "artificial." Like a host of other statements of similar popular origin, this is based on belief rather than experience and evidence and is not the view generally held. Bunge[1] has called attention to the lack of calcium (lime) and iron in sugar as compared with honey and sweet fruits. His contention that this might be a possible source of danger does not seem probable when one considers the varied character of our diet and its abundant supply of fruits and vegetables, milk products, and other foods which contain calcium and iron. The object sought is, of course, to supply in the diet all the substances which the body needs, and if this is done by the foods as a whole, the possible lack of a constituent or constituents in some single food which forms a part of the diet is not of importance. If for any reason calcium is lacking in the diet, the deficiency may be easily made good by increasing the amount of milk and milk products. Similarly, iron may be increased, if this is desirable, by taking more fruits, green vegetables, and the coarser milling products of the cereal grains, foods which are within the reach of practically everyone.

It will be noticed that sugar as it exists in nature—e. g., in the sugar cane, in milk, and in most fruits—is not highly concentrated. In milk it constitutes from 4 to 6 per cent. It would seem that the animal organism is best adapted to the utilization of food principles in the somewhat dilute or bulky form in which they occur in the commonly accepted foods—protein as found in meat, milk, etc., starch in grains, and sugar in small quantities at a time as found in vegetable juices and milk and in combination with other foods—and that it does not readily accept unlimited amounts of chemically isolated and purified food principles. Most of the statements which have been made regarding the amounts of sugar which are well tolerated depend upon evidence obtained in experiments in which the sugar

[1] Ztschr. Biol., 51 (1901), p. 155.

was used dissolved in liquid, as in tea, coffee, or some similar way, or from experience of the results which sometimes follow when a large quantity of sirup or candy or some similar product rich in sugar is taken. How far the conclusions drawn would apply to sugar taken in cake, pastry, custards, and other cooked foods can not be stated definitely, as few tests have been made upon the digestibility of such foods. With the exception of thick preserves and some similar foods, in which sugar is used as a preservative as well as a flavor, most cakes, custards, and other foods flavored with sugar contain it in moderate amounts, which means that the sugar is diluted or extended by a considerable quantity of other material. In this connection it may be said that it is the usual custom to take sugar in dilute form, as, for instance, when we add it to tea or coffee, sprinkle it on fruit, add it with milk or cream to breakfast cereals, or use it in other similar ways.

SUGAR AND THE TEETH.

It is often said that sugar is harmful to the teeth, but the facts seem to be as follows: According to the theory universally accepted, the decay of the teeth, technically called caries, is caused by bacteria, such as are found in every mouth, entering the soft portions of the teeth through defects in the hard outer covering. If acid is present in the mouth, and especially in the interstices of the teeth, it tends to eat into the enamel and thus provide an entrance for the caries-producing bacteria. Ordinarily, saliva is alkaline and protects the teeth against this danger, but when it is in contact with sugar or starch, acid is produced, hence a carbohydrate material lodged upon the teeth may be the indirect cause of caries. Some authorities hold that certain forms of sugar cause the flow of a less alkaline saliva, but this point is not fully established. In general, it is believed that starch is just as dangerous as sugar, and that the form and manner in which the material is eaten is a more important consideration than its exact chemical structure. Soft foods are especially likely to cause trouble, both because bits of them may remain on the teeth where they form "plaques" which are centers of bacterial action so long as they remain, and because they are swallowed without much chewing and thus do not rub the food "plaques" or other deposits from the teeth. Modern specialists consider that the cleansing action of proper mastication is as important for the preservation of the teeth as the regular use of a toothbrush, important as this last is. Any soft carbohydrate food eaten alone is much more likely to leave a deposit on the teeth than if it is eaten in combination with other foods. If candies are eaten by themselves, they are more likely to cause the development of acid in the mouth than if they are taken

during a meal. Some physicians advise finishing the meal with acid fruit for the sake of lessening the chances of carbohydrate material clinging to the teeth. While soft foods may possibly cause trouble, the hard ones may also be dangerous, especially to diseased teeth, as the effort to crush them may tend to increase flaws in the enamel. Such things as hard crusty food, hard candies such as lemon drops, stick candy, etc., may be dangerous in this respect, though investigations by G. V. Black[1] on the crushing force of the teeth have proved that sound teeth are capable of crushing much harder substances than these without injury.

EFFECT OF EXERCISE ON THE AMOUNT OF SUGAR WHICH MAY BE EATEN.

The amount of sugar that may be eaten without bad effects depends much on the amount of exercise taken. It has been observed that a man doing hard work in the open air can easily assimilate large quantities of sugar, while the same quantity would cause indigestion if eaten when living indoors and taking little exercise. This is what might be expected, as the active outdoor life means much physical work or exercise, either of which involves much muscular energy. Sugar, as has been pointed out, is a valuable energy-yielding food.

SUGAR IN COOKING, PRESERVING, AND CONFECTIONERY.

Sugar is used in cookery, in the manufacture of confectionery, which is almost entirely sugar, and as an addition to a great variety of foods. It is almost always used with cooked fruit, cakes, pastry, and, in general, food made with eggs and flour, and very rarely with meat dishes in modern cookery, though often added in earlier times, as old recipe books show, to meat pies, which were heavily seasoned with sugar and spice. Mince pie is one of the very few surviving representatives of such foods. Sugar and fat are often cooked together, and many foods, butter-scotch for example, owe their pleasing flavor to this combination. Sugar and suet are often used, as in puddings, but less often now than formerly.

Sugar added in cakes and pastry affects the texture as well as the composition and flavor, as any cook knows. A special form of cookery is the making of preserves, jams, jellies, etc., and in these sugar in thick, heavy solution not only adds to the palatability and character of the flavor, but it also acts as a preservative. On the contrary, thin solutions of sugar alone or with fruit juices, etc., are very readily subject to decomposition by microorganisms. Hence, in order that it may act as a preservative, a solution of sugar must be concentrated.

Without doubt more sugar is used in cookery and in making jams,

[1] A work on operative dentistry, Chicago and London, 1908, Vol. I, p. 161.

jellies, and preserves, and in making confectionery (which is a special form of cookery) than in any other way. In general it may be said that for ordinary cakes the proportion of sugar is not usually greater than one part by measure to two parts of flour, and that too much sugar should not be used in making puddings, cakes, etc., since oversweetening, like other forms of overflavoring, is regarded as a mark of unskilled cookery. In the case of canned fruits a common proportion is one part of sugar to two parts of fruit by weight; for preserves, equal parts of sugar and fruit; and for jellies, three-quarters to one part by weight of sugar to one part of juice.

Detailed recipes for making preserves, jellies, and similar articles are given in earlier bulletins [1] in this series. Directions for making cakes, pies, puddings, and other such dishes in which sugar is an important part can be found in cookbooks and similar publications.

Candy of the better grade is very largely made up of sugar, with the addition of various coloring matters and flavors, nuts, fruit, etc., and sometimes fat, starch, and commercial glucose. The food value of most candies may be expressed by the amount of the sugar contained (72 to 96 per cent), but as regards wholesomeness the other ingredients must be taken into account. The coloring matters used in cheap candies are nearly all compounds of anilin or other coal-tar products, some of which are thought to be harmless. Some of the coloring matters and flavors used, however, have been shown to be harmful. Ordinary caution would suggest that children, at least, be allowed to partake very sparingly of such unknown compounds. Two hundred and fifty samples of cheap candy examined by the Bureau of Chemistry of this department a few years ago were found to be made up largely of commercial glucose with a little sugar and starch. Candies are often exposed to the dust and dirt in stores and booths, taken out of jars and boxes by dirty hands, or weighed in scales of questionable cleanliness. Dangerous microorganisms such as are frequently present in dust may thus lodge on them and be eaten with the candy. Cleanliness in the marketing of this class of goods is just as necessary as in the case of fruits or vegetables, perhaps more so, as the others can be washed if they are to be eaten raw, and candies would not be washed.

Studies recently made in Pennsylvania [2] show that while there has been marked improvement in the quality of cheap candies during the last few years, there is room for still greater improvement in the form of these candies and the method of marketing them. Many are made in the form of whistles, marbles, belts, and necklaces, which the children often play with and which become very dirty before they

[1] U. S. Dept. Agr., Farmers' Buls. 203, Canned Fruit, Preserves, and Jellies—Household Methods of Preparation; 359, Canning Vegetables in the Home; and 426, Canning Peaches on the Farm.

[2] Pennsylvania Dept. Agr., Dairy and Food Div. Bul. 216.

are eaten. The desirability of having candies wrapped or at least protected from dust and dirt while exposed for sale is evident.

The custom of marketing candies wrapped or of packing them in boxes, etc., at the factory is a growing one, particularly with the more expensive sorts, and is certainly a measure which makes for cleanliness. With respect to the candies themselves, manufacturers who realize their responsibility endeavor to insure sanitary conditions in their manufactories. In a number of States the candy factories, like like other food manufactories, are inspected under State auspices.

SUGAR IN FRUITS.

A large number of studies of fruits and fruit products by the California experiment station indicate that the food value of fruits is largely due to the various sugars they contain, the ones most commonly found being cane sugar, grape sugar or dextrose, and fruit sugar or levulose, the last two usually present together in equal quantities, in which case they are collectively known as invert sugar, though sometimes not in equal quantities, in which case they are called reducing sugar.

The stage of growth and the degree of ripeness have a very decided effect on the kind and amount of sugar present in fruits, and it is therefore difficult to give average figures which will fairly represent the quantities present. According to figures published several years ago, invert sugar ranges from about 2 per cent in large early apricots to 15 per cent in grapes and a variety of sweet cherries, while strawberries, gooseberries, raspberries, and apples contain about half the latter quantity. The cane sugar ranges from less than 1 per cent in lemons to 14 per cent in a variety of plums. Ripe bananas were also found to contain a fairly high percentage, namely, 11 per cent.

Dried fruits, like figs, dates, and raisins, which have been concentrated by evaporation, naturally contain much greater proportions of sugar than fresh fruits, the amount of levulose reported being sometimes over 50 per cent. The use of such sweet fruits for sweetening cooked breakfast cereals and other dishes is by no means uncommon. The question of the sugar content of fresh fruits and dried fruits and their value as food has been discussed in earlier publications.[1]

Jams, jellies, and similar products almost always contain added sugar, and hence their nutritive value may be considerable. Homemade jams are often cooked longer than the commercial ones, and therefore may contain a larger proportion of invert sugar. On the other hand, commercial brands are often made with glucose, but the law requires that the fact be stated on the label, along with the proportions of chemical preservatives, etc., if present. (See also p. 10.)

[1] U. S. Dept. Agr., Farmers' Bul. 293, Use of Fruit as Food; U. S. Dept. Agr., Yearbook 1912, p. 505, Raisins, Figs, and Other Dried Fruits, and Their Uses as Food.

SUGAR IN THE DIETARIES OF CHILDREN.

The amount of sugar to be given children and in what form is a question of much importance. Sugar would seem to be a food especially adapted to children because of their great activity. The relatively small body of the child loses more heat from the skin for every pound of body weight than does the larger person, and children, on this account and because of their active life, require proportionally more heat units in their food than do adults.

Fat, especially fat meat, which could readily supply this need, is often disliked by the child, and his relish for all kinds of sweets has doubtless a physiological basis. It is to be remembered, however, that before the introduction of cane sugar as we now know it countless generations of children had been reared without its help. The digestibility of sugar and sweetened foods for children and their influence on the appetite for other foods must decide to what extent sugar is to replace starch in the dietary and how far it may be safely used as a flavor.

Until a child's stomach is capable of digesting starch the needed carbohydrate is furnished in the sugar of milk, the child a year old who drinks 2 quarts of milk a day taking in this way about 3 ounces of milk sugar. As the stomach becomes able to digest starch the child is less and less dependent on the sugar of milk, replacing it with the carbohydrates of vegetable origin, while the protein and fat found in eggs, meat, breakfast cereals, and bread and butter take the place of those constituents that were at first exclusively furnished in milk. Milk, however, remains throughout childhood a valuable source of all these food principles.

The fact that sugar has a high food value is not the only point to be considered. The child will easily obtain the needed carbohydrates in other forms, and will thrive if its digestion remains sound and its relish for wholesome food unimpaired. For instance, one often hears it said that a certain child does not relish milk. In such cases it might be found that the child's appetite, being sated by sugar in other foods, is no longer attracted by the mild sweetness of fresh milk, delicious as it is to the unspoiled palate. It would be well, perhaps, in this instance to cut down the allowance of sugar in the hope of restoring the taste for so invaluable a food as milk. Many believe that the infant, even in its second year, should not be permitted to taste sweets, in order to prevent perversion of the appetite. Even much later, for the same reason, the introduction of large amounts of sugar into the daily food of children is to be carefully considered. Children do not require a variety of flavors to stimulate the appetite, but the taste is easily perverted and the restoration of a normal appetite is difficult. Those who have studied the food

habits of children seem to agree that sugar should from the very first be withheld from the dish that forms the staple food of the child—that is, the mush or porridge of oatmeal or other cereal. This article of diet, eaten only with milk or cream, falls into the same class as bread and milk and forms the simple, wholesome basis of a meal. The sugar given the child is better furnished in the occasional simple pudding, in the lump of sugar, or homemade candy, not that its food value is better utilized, but that the whole diet of the child is thus made more wholesome. In sweet fruits, fully ripened, the child finds sugar in a healthful form, and they should be freely furnished.

COMPARATIVE COST OF SUGAR AS FOOD.

Ten cents' worth of sugar at 6 cents per pound would furnish 2,920 calories of energy. At 6 or 7 cents per pound sugar compares favorably with other foods as a source of energy, although it is more expensive than starch in the form of such cereal foods as wheat flour, corn meal, and oatmeal, which contain 65 to 80 per cent of carbohydrates and, in addition, 10 to 14 per cent of protein, and cost from 2.5 to 4 cents per pound. Judging from the results of many dietary studies, the average cost of sugar in the daily ration is about 2 cents, and, compared with some other common foods, sugar is not an expensive item in the dietary.

GENERAL CONCLUSIONS.

One may say in general that the wholesomeness of sweetened foods and their utilization by the system is largely a question of quantity and concentration. For instance, a simple pudding flavored with sugar rather than heavily sweetened is considered easy of digestion, but when more sugar is used, with the addition of eggs and fat, we have as the result highly concentrated forms of food, which can be eaten with advantage only in moderate quantities and which are entirely unsuited to children and invalids.

It is true that the harvester, lumberman, and others who do hard work in the open air consume great amounts of food containing considerable quantities of sugar, such as pie and doughnuts, and apparently with impunity; but it is equally true that people living an indoor life find that undue amounts of pie, cake, and pudding, with highly sweetened preserved fruit, and sugar in large amounts on cooked cereals, almost always bring indigestion sooner or later.

From a gastronomic point of view it would seem also that in the American cuisine sugar is used with too many kinds of food, with a consequent loss of variety and piquancy of flavor in the different dishes. The nutty flavor of grains and the natural taste of mild fruits are very often concealed by the addition of large quantities of sugar.

In the diet of the undernourished larger amounts of sugar would doubtless help to supply adequate nutrition. This point is often urged by European hygienists. In the food of the well-to-do it is often the case, however, that starch is not diminished in proportion as sugar is added. That sugar, on account of its agreeable flavor, furnishes a temptation to take more carbohydrate food than the system needs can not be denied. The vigor of digestion and muscular activity in each particular case would seem to suggest the limit. A lump of sugar represents about as much nutriment as an ounce of potato, but, while the potato will be eaten only because hunger prompts, the sugar, because of its taste, may be taken when the appetite has been fully satisfied.

Sugar is a useful and valuable food. It must, however, be remembered that it is a concentrated food, and therefore should be eaten in moderate quantities. Further, like other concentrated foods, sugar seems best fitted for assimilation by the body when supplied with other materials which dilute it or give it the necessary bulk.

Persons of active habits and good digestion will add sugar to their food almost at pleasure without inconvenience, while those of sedentary life, of delicate digestion, or with a tendency to corpulency would do better to use sugar very moderately. It is generally assumed that 4 or 5 ounces of sugar per day is as much as it is well for the average adult to eat under ordinary conditions.

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535

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